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Description

Simplified Adaptive Control Method for Power Converters

BACKGROUND OF INVENTION

[0001] This invention relates to power converters and more particularly to adaptive control techniques for controlling such converters. The applicant's prior U.S. patent no. 5,438,505 discloses a power converter regulating technique based on forcing the input current of a converter to follow a signal proportional to the ratio of the output current of the converter to its output voltage (the conductance of the converter's load) or to the ratio of output voltage of the converter to its output current (the resistance of the converter's load).The performance provided by this technique is excellent but the algorithms are calculation intensive so the technique may not be cost-effective for low-end applications. It is an object of the present invention to provide a simplified adaptive control technique that will maintain most of the benefits of the

technique disclosed in the U.S. patent no. 5, 438, 505.

Summary of Invention

[0002] The present invention exploits the fact that the filters at the output of power converters consist of relatively large capacitors and inductors that reduce the variation of the output voltage and current of the converter as a result of sudden loads changes.

[0003] If the output current or the output voltage of the converter changes relatively slowly as a result of a load transient, a simplified control algorithm can be used that does not require the calculation of the voltage to current ratio (the resistance of the load) or the current to voltage ratio (the conductance of the load). The algorithm of the present invention will use the output current or the output voltage of the converter instead of the conductance or resistance of the load.

Brief Description of Drawings

[0004] Figure 1 is a block diagram of a converter control based on the prior art.

[0005] Figure 2 is the block diagram of control for converters intended to operate as voltage sources.

[0006] Figure 3 is the block diagram of control for converters in-

tended to operate as current sources.

[0007] Figure 4 is the block diagram of a further simplified control for converters intended to operate as voltage sources.

[0008] Figure 5 is the block diagram of a further simplified control for converters intended to operate as a current sources.

Detailed Description

[0009] If converter 1 in figure 2 has 100% efficiency, its average input power is equal to its average output power:

[0010] 1 $V_i \cdot I_i = V_o \cdot I_o$

[0011] Converter 1 is equipped with an internal control loop that forces its input current to be equal with a control signal Vc:

[0012] 2 $I_i = k \cdot Vc$

[0013] According to one embodiment of the present invention (ref. Fig. 2), the output voltage of converter 1 can be regulated by making reference Vc proportional to the output current Io of the converter and inversely proportional to the input voltage V_i. If the proportionality constant is unity, the control voltage Vc will be equal to:

[0014] 3 $Vc = I_o / V_i$

[0015] Substitutions into equation 2 and 1 yields:

[0016] 4 $V_i \cdot k \cdot I_o / V_i = V_o \cdot I_o$

[0017] If the output current $I_o > 0$, we can divide both sides of equation 3 by I_o. The input voltage Vi cancels out, yielding:

[0018] 5 $V_o = k$

[0019] meaning that the output voltage is regulated in respect to changes in both the input voltage and output load.

[0020] In some applications (ref. Fig. 3) it might be desirable to operate converter 1 is a current source. In such cases, reference V_c is made proportional to the output voltage Vi of the converter and inversely proportional to the input voltage V_i. If the proportionality constant is unity, the control voltage V_c will be now equal to:

[0021] 6 $V_c = V_o / V_i$

[0022] Substitutions into equation 2 and 1 yields:

[0023] 7 $V_i \cdot k \cdot V_o / V_i = V_o \cdot I_o$

[0024] If the output voltage is larger than 0, we can divide both sides of equation 3 by V_o. The input voltage Vi cancels out, yielding:

[0025] 8 $I_o = k$

[0026] meaning that the output current is regulated in respect to

changes in both the input voltage and output load.

[0027] According to equations 5 and 8, the control method of the present invention will yield perfect regulation of the output current or voltage of an ideal, 100% efficient converter, provided that all the constants are perfectly accurate and stable and all the mathematical operations are perfectly accurate. In reality, the efficiency of converters is always less than 100%, mathematical operations may not be perfectly accurate and constants tend to drift with time and temperature.

[0028] In order to compensate for these errors and improve regulation, a slow, relatively high gain conventional closed loop can be added that will compare the output voltage (or current) of the converter with an appropriate reference and alter the proportionality constants so the output current or voltage of regulated to the desired degree of accuracy.

[0029] In an yet simpler embodiment of the present invention, the control voltage Vc is made proportional only to either the output current (ref. Fig 4) or the output voltage, resulting in an output Vo or respectively an output current Io that are not affected by changes in the output load but are proportional to the input voltage.

[0030] This embodiment of the present invention will be applied for converters operated with constant (no correction for input voltage changes required) or slowly varying input voltage, where line regulation can be provided by the added conventional loop.

[0031]